METHOD AND COMPOSITION FOR ATTRACTING ARTHROPODS BY VOLATILIZING AN ACID

Cross Reference to Related Applications

This application is a continuation-in-part of copending U.S. Patent Application Serial No. 10/243,590 filed September 13, 2002, which is incorporated by reference herein in its entirety.

Field of the Invention

The present invention relates to methods of attracting arthropod pests and more particularly to methods of attracting arthropods by volatilizing an acid.

Background of the Invention

Arthropods have plagued humans for centuries. Many types of arthropods (such as mosquitoes, ticks, fleas, sand flies, and midges) are nuisances to human populations because they bite, spread human and veterinary diseases, and cause crop or other property damage. For example, many types of mosquitoes are known to be significant factors in the spread of diseases such as malaria, encephalitis, and West Nile virus. Termites cause almost $2 billion in property damage per year in the United States alone. Therefore, it is important to develop means of controlling populations of arthropods to control the spread of disease and minimize property damage.

A first step to controlling arthropod populations often involves attracting the arthropods in an area to a specific location. Once narrowed to a location, the arthropods can be trapped, killed, or otherwise treated to affect the spread of present and future generations. Attractants can also be used to divert arthropods from a certain location, or for research purposes.

Many arthropods, such as mosquitoes, fleas, and ticks, are naturally attracted to humans and other animals. Light and carbon dioxide are two of the more commonly employed attractants. Other volatile compounds such as L-lactic acid, octenol, acetone, and pheromones have also been used as mosquito attractants.

There is a need in the art to provide a better method for attracting arthropods in large quantities beyond what is feasible using prior art methods.

Summary of the Invention

The present invention provides a method and composition for attracting arthropods (e.g., mosquitoes) by using a volatile acid (e.g., a humidified volatile acid) in gaseous form. Such volatile acids have been found to be arthropod attractants and, when combined with carbon dioxide, provide greater attraction than carbon dioxide alone. The volatile acid precursor can be provided adjacent an arthropod trapping device and at least a portion of the attracted arthropods can be trapped. Alternatively, the humidified volatile acid precursor can be used in conjunction with a pesticide and the pesticide can be used to kill at least a portion of the attracted arthropods. Alternatively, carbon dioxide gas can be forced over an impregnate bed which may be, for example, zeolites impregnated with a volatile acid and/or water in a packed bed.

In one embodiment of the invention, the arthropods are attracted by exposing a volatile acid precursor to water to produce a volatilized acid. Preferably, the volatile acid precursor combines with water to produce an acid such as hydrogen chloride or HBr. In accordance with this embodiment, the volatile acid precursor can be a hydrate of ferric chloride such as ferric chloride hexahydrate. The volatile acid precursor can be impregnated in a carrier and can be provided in a gas permeable sachet. The volatile acid precursor can be exposed to water, for example, through exposure to water vapor in the atmosphere, the intentional addition of liquid water, or contact with water produced by a chemical reaction.

In accordance with the invention, a humidified volatized acid can be combined with carbon dioxide to enhance the ability of the humidified volatized acid to attract arthropods. The carbon dioxide can be provided, for example, through the use of carbon dioxide canisters, the sublimation of dry ice, the burning of an organic fuel (e.g. propane or butane), or through a chemical reaction (e.g., a chemical reaction involving yeast generators.) Preferably, the carbon dioxide is produced by exposing a carbon dioxide precursor such as a carbonate, bicarbonate or sesquicarbonate (e.g. sodium bicarbonate) to an acid.

In accordance with one embodiment of the invention, at least one of the volatile acid precursor and the carbon dioxide precursor can be impregnated in a carrier. According to one embodiment of the invention, both of the volatile acid precursor and the carbon dioxide precursor can be impregnated in carriers and can further be provided in a gas permeable sachet.

Furthermore, in accordance with the invention, the humidified volatized acid can be created from an acid having low volatility and salt of a volatile acid. In particular, arthropods can be attracted by combining a low volatility acid and a salt of a volatile acid salt in aqueous solution to produce a volatilized acid. Preferably, according to this embodiment, the low volatility acid is L-lactic acid. The preferred volatile acid salt is sodium chloride and the combination produces small amounts of hydrogen chloride as the volatilized acid.

These and other features and advantages of the present invention will become more readily apparent to those skilled in the art upon consideration of the following detailed description, which describes both the preferred and alternative embodiments of the present invention.

Detailed Description of the Preferred Embodiments

In the following detailed description, preferred embodiments are described in detail to enable practice of the invention. Although the invention is described with reference to these specific preferred embodiments, it will be understood that the invention is not limited to these preferred embodiments. But to the contrary, the invention includes numerous alternatives, modifications, and equivalents as will become apparent from consideration of the following detailed description. The term "comprising" and variations thereof as used herein is used synonymously with the term "including" and variations thereof and is an open, non-limiting term. Furthermore, although terms such as "volatile acid precursor", "carbon dioxide precursor", "low volatility acid" and the like are described herein in singular form, these terms can include combinations of these components. For example, although a volatile acid precursor is described herein, it can include more than one volatile acid precursor in combination as described and as claimed.

In accordance with the invention, arthropods are attracted through the use of a humidified volatile acid vapor. Preferably, the volatile acid is an acid such as hydrogen chloride, H_2S, SO_2, SO_3, acetic acid or H_3PO_4.

The volatile acid is preferably produced by exposing a volatile acid precursor to water. Preferably, the volatile acid precursor combines with water to produce an acid such as hydrogen chloride. The volatile acid precursor is typically a salt of an acid and can be provided in hydrated or anhydrous form. Preferably, the volatile acid precursor is a hydrate of ferric chloride such as ferric chloride hexahydrate. The volatile acid precursor can be exposed to water through exposure to water vapor in the atmosphere, the intentional addition of liquid water, or contact with water produced by a chemical reaction. More particularly, in one example, the volatile acid precursor can be exposed to water as water is produced as a by-product of a reaction between ferric chloride and another substance, such as a carbonate salt. Deliquescents, such as $CaCl_2$ and $MgCl_2$ are especially useful in exposing the volatile acid precursor to water.

The volatile acid precursor can be provided in particulate form (e.g., a powder), or can be impregnated in a porous carrier. Preferably, the porous carrier is an inert carrier in the form of carrier particles having pores, channels or the like located therein. In addition, the volatile acid precursor is preferably uniformly impregnated within the porous carrier. Suitable carriers include silica, alumina, zeolite crystals, pumice, diatomaceous earth, bentonite, or clay (e.g. aluminum silicate or kaolin). Preferably, the porous carrier includes diatomaceous earth or zeolite crystals. The volatile acid precursor can be provided in a gas permeable sachet (e.g. a TYVEK® sachet) or can be put into a packed flow through column.

In one example, the carrier particles include 0.1% to 80% of the volatile acid precursor and more preferably 30 to 70% of the volatile acid precursor by weight.

In accordance with the invention, the volatized acid can be combined with carbon dioxide to enhance the ability of the volatized acid to attract arthropods. The carbon dioxide can be provided through the use of carbon dioxide canisters, through a combustion reaction (e.g. propane combustion) or by the sublimation of dry ice or yeast generators. Preferably, the carbon dioxide is produced by exposing a carbon dioxide precursor such as a carbonate, bicarbonate or sesquicarbonate to an acid. Suitable carbon

dioxide precursors are described in related U.S. Application No 10/243,590 filed on September 13, 2002 and preferred carbon dioxide precursors include sodium carbonate and sodium bicarbonate. The carbon dioxide precursors can be provided as a powder or impregnated in a carrier. Suitable carriers and methods of producing impregnated carrier particles are described above and in U.S. Application No 10/243,590. The carbon dioxide precursor can be provided in a gas permeable sachet.

In one preferred embodiment of the invention, ferric chloride hexahydrate is used as the volatile acid precursor and sodium bicarbonate is used as the carbon dioxide precursor. As discussed above, other volatile acid precursors and carbon dioxide precursors can be used. In this preferred embodiment, ferric chloride hexahydrate combines with water to produce hydrochloric acid. The hydrochloric acid then reacts with sodium bicarbonate to form carbon dioxide and water. The water of reaction combines with ferric chloride hexahydrate to form more hydrogen chloride. Some of the hydrogen chloride reacts with the sodium bicarbonate to produce more carbon dioxide and water, while some of the hydrogen chloride volatilizes and leaves the reaction mixture along with the carbon dioxide. Some of the water also leaves as water vapor that humidifies the gas mixture.

The volatized acid can also be produced from an acid having low volatility to attract mosquitoes in accordance with the invention. In this embodiment, a low volatility acid is combined with a salt of a volatile acid. The interaction of these materials produces a volatile acid such as hydrogen chloride. Preferably, the low volatility acid is L-Lactic acid and the salt is sodium chloride, KCl, LiCl, MgCl2, or $CaCl_2$. Suitable low volatility acids include weak organic acids such as L-lactic acid.

Preferably, the low volatility acid and the volatile acid salt are used in a concentrated aqueous solution. For example, the concentrated aqueous solution can include greater than 1M of each of the low volatility acid and the volatile acid salt. In particular, at the higher concentration, an ion exchange occurs such that, for example, NaCl and lactic acid produce sodium lactate and HCl, a volatile acid. One method of producing the concentrated aqueous solution is to begin with a less concentrated solution and to allow the water in the solution to evaporate.

As a result of the invention, arthropods are attracted to the volatilized acid, and the attracted arthropods can be diverted from a specific area, trapped, killed, or otherwise modified to reduce the overall population of the arthropod in the area. For example, the volatile acid precursor and other components discussed above can be provided adjacent to a trap for arthropods, e.g., a mosquito trap. Alternatively, carbon dioxide gas can be pushed through a bed of acid impregnated media, or acid releasing media to effectively humidify and acidify the carbon dioxide gas. Specifically, the volatile acid precursor can be provided in or on the trapping device. The attracted arthropods can also be killed using a pesticide. For example, the volatile acid precursor and other components discussed above can be mixed with a pesticide for use in the invention.

The invention will now be further described by the following non-limiting examples.

Example 1: Ferric chloride activation

100 Aedes aegypti (AE) mosquitoes were placed into an olfactometer unit. For each test, the mosquitoes were exposed to two sets of stimuli for a collection period of 3 minutes. The mosquitoes could chose between the stimuli or not respond. The data is reported in Table 1.

For the first test, ferric chloride hexahydrate was impregnated on diatemaceous earth and was activated with a moisture containing substance to form the first stimulus center. This material released water and trace amounts of hydrochloric acid, HCl. The second stimulus center in this test was a blank (no chemical stimulus).

For the second test, dry carbon dioxide was fed at 5 ml/min from a standard gas cylinder as the first stimulus center. The second stimulus center in this test was a blank (no chemical stimulus). The carbon dioxide alone attracted some of the insects but in general did not draw significant numbers.

For the third test, ferric chloride hexahydrate was impregnated on diatemaceous earth and was activated with a moisture containing substance to form the first stimulus center. This material released water and trace amounts of hydrochloric acid, HCl. The second stimulus center was dry carbon dioxide fed at 5 ml/min from a standard gas cylinder. The data shows a higher percentage of mosquitoes responded to the stimulus

provided by the activated ferric chloride material. In comparison with carbon dioxide, the ferric chloride impregnate attracted substantially more mosquitoes.

Table 1 – Average Percent AE Attracted

Stimulants	Stimulant 1 - Avg. % attracted	Stimulant 2 - Avg. % attracted
Activated Ferric Chloride v. Blank	51	1
CO_2 (Dry) v. Blank	21	0
Activated Ferric Chloride v. CO_2	70	12

Example 2: Activated ferric chloride hexahydrate with sodium bicarbonate sachet

As with Example 1, 100 AE mosquitoes were placed into an olfactometer unit. For each test, the mosquitoes were exposed to two sets of stimuli for a collection period of 3 minutes. The mosquitoes could chose between the stimuli or not respond. The data is reported in Table 2.

For the first test, dry carbon dioxide was fed at 5 ml/min from a standard gas cylinder as the first stimulus center. The second stimulus center in this test was a blank (no chemical stimulus).

For the second test, ferric chloride hexahydrate impregnated on diatemaceous earth and sodium bicarbonate powder were contained in a sachet. The sachet was activated by combining the two powders stimulating a chemical reaction that released carbon dioxide, water and trace amounts of hydrochloric acid, forming the first stimulus center. The reaction produces by-product water that stimulates hydrochloric acid production from the ferric chloride. The sachet was designed to release CO_2 at a rate of 5 ml/min over the collection period. The second stimulus center in this test was a blank (no chemical stimulus).

For the third test, a sachet containing ferric chloride hexahydrate impregnated on diatemaceous earth and sodium bicarbonate powder, similar to the sachet used in the second test, was activated with a moisture-containing substance to release carbon dioxide water and trace amounts of hydrochloric acid, forming the first stimulus center. The reaction produces by-product water that stimulates hydrochloric acid production from the ferric chloride. The second stimulus center was carbon dioxide fed at 5 ml/min from a standard gas cylinder.

The data shows the majority of mosquitoes responded to the stimulus provided by the carbon dioxide and hydrochloric acid releasing sachet. In comparison with carbon dioxide alone, the sachet attracted substantially more mosquitoes.

Table 2 – Average Percent AE Attracted

Stimulants	Stimulant 1 - Avg. % attracted	Stimulant 2 - Avg. % attracted
CO_2 (Dry) v. Blank	21	0
CO_2/HCl/H_2O Sachet v. Blank	96	0
CO_2/HCl/H_2O Sachet v. CO_2	93	2

Example 3: Activated ferric chloride hexahydrate with sodium bicarbonate sachet

As with Examples 1 and 2, 100 AE mosquitoes were placed into an olfactometer unit. For each test, the mosquitoes were exposed to two sets of stimuli for a collection period of 3 minutes. The mosquitoes could chose between the stimuli or not respond. The data is reported in Table 3.

For the first test, ferric chloride hexahydrate impregnated on a diatemaceous earth was activated with a moisture containing substance to form the first stimulus center. This material released water and trace amounts of hydrochloric acid, HCl. The second stimulus center in this test was a blank (no chemical stimulus).

For the second test, a sachet containing ferric chloride hexahydrate impregnated diatemaceous earth and sodium bicarbonate powder was used, similar to the sachet used in Example 2. The sachet was activated by combining the two powders stimulating a chemical reaction that released carbon dioxide, water and trace amounts of hydrochloric acid, forming the first stimulus center. The reaction produces by-product water that stimulates hydrochloric acid production from the ferric chloride. The sachet was designed to release carbon dioxide at a rate of 5 ml/min. The second stimulus center in this test was a blank.

For the third test, a sachet identical to that used in the second test and containing ferric chloride hexahydrate impregnated on diatemaceous earth and sodium bicarbonate powder was activated, forming the first stimulus center. The second stimulus center in this test was ferric chloride hexahydrate impregnated on diatemaceous earth and activated with a moisture containing substance to form hydrogen chloride, as in Example 1.

For the fourth test, a sachet containing ferric chloride hexahydrate impregnated on diatemaceous earth and sodium bicarbonate powder, identical to that in the first test, was activated to form the first stimulus center. The second stimulus center had two components. The first component was activated ferric chloride hexahydrate impregnated on diatemaceous earth, as in Example 1. The second component of the second stimulus center was dry carbon dioxide fed at 5 ml/min from a standard gas cylinder.

The data shows the majority of mosquitoes responded to the stimulus provided by the carbon dioxide-releasing reactions. The sachet was also compared to the activated

ferric chloride with a separate dry carbon dioxide source (test 3). The activated ferric chloride did enhance the attractive capability of the carbon dioxide alone. However, the sachet was substantially more stimulating to the mosquitoes than any of the other stimulus centers.

Table 3 – Average Percent AE Attracted

Stimulants	Stimulant 1 - Avg. % attracted	Stimulant 2 - Avg. % attracted
Activated Ferric Chloride v. Blank	51	1
CO_2/HCl/H_2O Sachet v. Blank	96	0
CO_2/HCl/H_2O Sachet v. Activated Ferric Chloride alone	54	34
CO_2/HCl/H_2O Sachet v. Activated Ferric Chloride plus CO_2	63	26

Example 4

As with Examples 1, 2 and 3, 100 Aedes aegypti (AE) mosquitoes were placed into an olfactometer unit. For each test, the mosquitoes were exposed to two sets of stimuli for a collection period of 3 minutes. The data is reported in Table 4.

In these tests, dry CO_2, flowing at 5 mL/min was passed through either a hollow tube, or through a cartridge containing a bed of porous media impregnated with either water, HCl solution, or ferric chloride hexahydrate. The point at which the CO_2 entered the olfactometer was considered a stimulus center.

For the first test, the first stimulus center received CO_2 that had flowed through a bed of ferric chloride hexahydrate on porous carrier. The second stimulus center was blank (no chemical stimulus).

For the second test, the first stimulus center received CO_2 that had flowed through a hollow tube. The second stimulus center was blank (no chemical stimulus).

For the third test, the first stimulus center received CO_2 that had flowed through a bed of water on porous carrier. The second stimulus center was blank (no chemical stimulus).

For the fourth test, the first stimulus center received CO_2 that had flowed through a bed of HCl solution on porous carrier. The second stimulus center received CO_2 that had flowed through a bed of water on porous carrier.

For the fifth test, the first stimulus center received CO_2 that had flowed through a bed of ferric chloride hexahydrate on porous carrier. The second stimulus center received CO_2 that had flowed through a bed of water on porous carrier.

For the sixth test, 5 mL/min of CO_2 was passed through a hollow tube and blown over the surface of water in a Petri dish to form the first stimulus center. Also, 5 mL/min of CO_2 as passed through a hollow tube to form the second stimulus center.

The data shows that CO_2 (dry) is an attractant for mosquitoes. However, CO_2, humidified CO_2, or humidified CO_2 containing HCl are better attractants than dry CO_2. The data also shows that humidified CO_2 containing HCl is a better attractant than humidified CO_2.

Table 4 – Average Percent AE Attracted

Stimulants	Stimulant 1 - Avg. % attracted	Stimulant 2 - Avg. % attracted
CO_2 / cartridge of carrier impregnated with Ferric chloride vs blank	93	1
CO_2 (dry) / tube vs blank	15	0
CO_2 / cartridge of carrier impregnated with water vs blank	88	0
CO_2 / cartridge of carrier impregnated with HCl vs CO_2 / cartridge of carrier impregnated with water	73	13
CO_2 / cartridge of carrier impregnated with Ferric chloride vs CO_2 / cartridge of carrier impregnated with water	48	40
CO_2 flowing over water surface versus CO_2 (dry)	43	7

It is understood that upon reading the above description of the present invention and reviewing, one skilled in the art could make changes and variations therefrom. These changes and variations are included in the spirit and scope of the following appended claims.